What happens to DUNE-DP detector components when arriving to SD

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Summary

This is not a exhaustive list of what must be installed

Light readout
- 720 TPB coated PMTs

Charge readout
- 80x CRP
- 80x 3 suspensions
- 80x 12 SGFT
- 80x 1 instrumentation feedthroughs

VHV system
- 1 feedthrough and connection to the cathode
- 12 super-modules field cage assemble underground
- 20 cathode bridges assembled underground

Detector ground racks

Charge readout, Light readout, CRP movement,
LEM HV PS, Detector safety system, Detector Control System,
Instrumentation, Rack power distribution, VHV power supply

Light readout

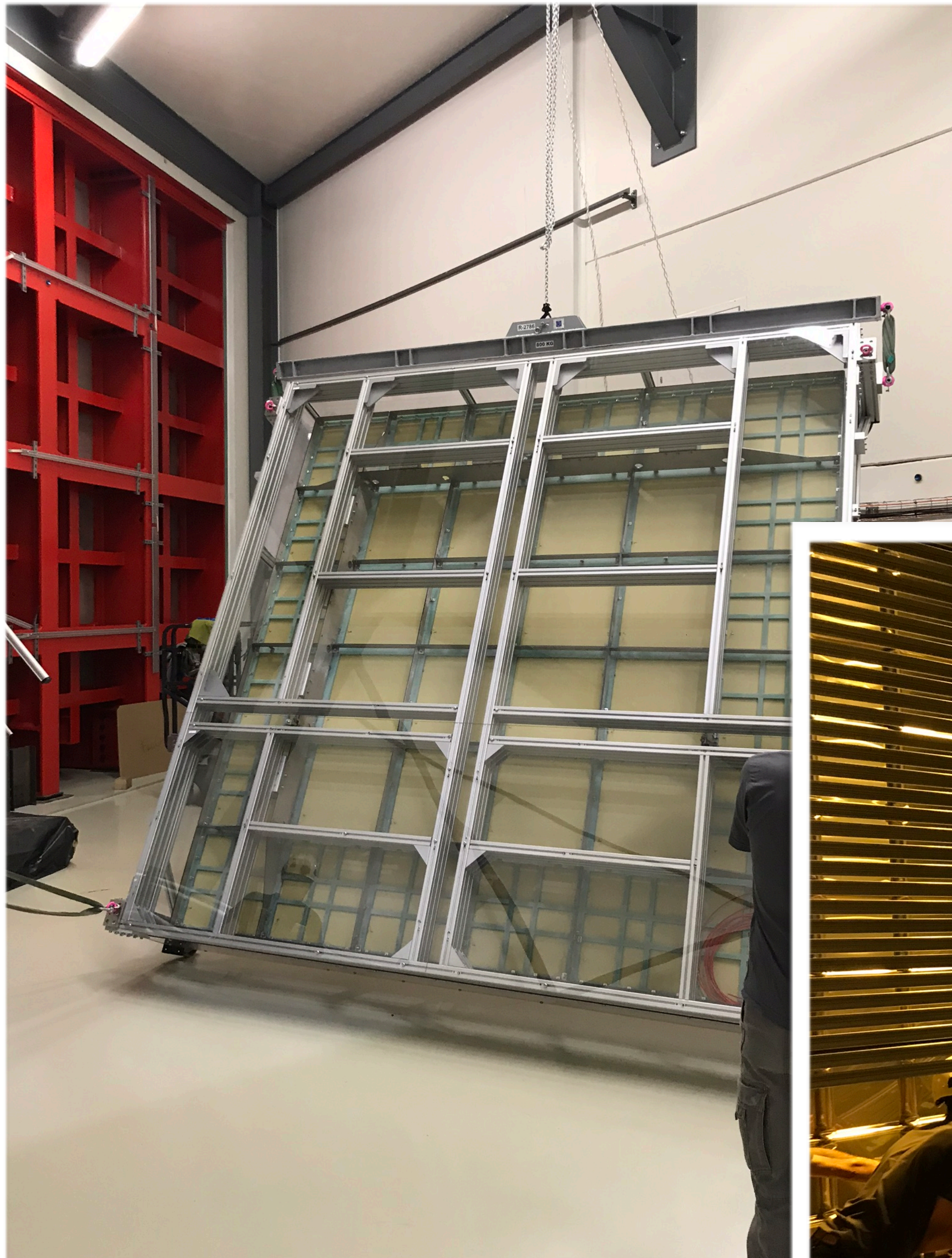
720 + spare 8'' PMTs coated with TPB.
PMTs will arrive in boxes 150 cm x 60 cm x 60 cm (10 PMTs) ~50 kg.
Required dry space for storage. Possibly requirements on the temperature control.
TPB coating not necessarily done at the ITF. Possibilities under discussion.
Possibly PMTs are tested and evaporated at the production sites.
Need a clean lab space where to test PMTs (gain and QE) and fix issues.

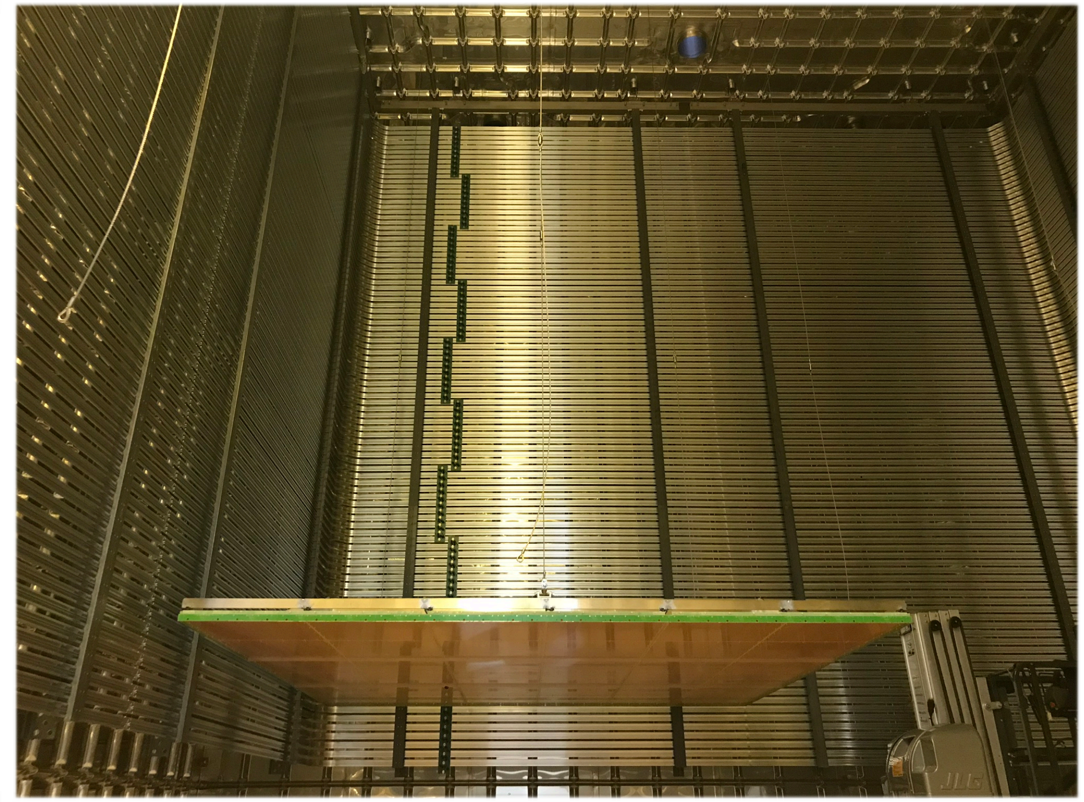
If it turns out that the evaporation must be done in South Dakota, also needed:
Space for the evaporation facility. From NP02 to be scaled:
One evaporator (vacuum chamber O(1 m^3)) housing a single PMT (2 PMT/day)
in a clean room with crane to open and close the vacuum chamber.
Need more evaporators working in parallel each one hosting several PMTs.

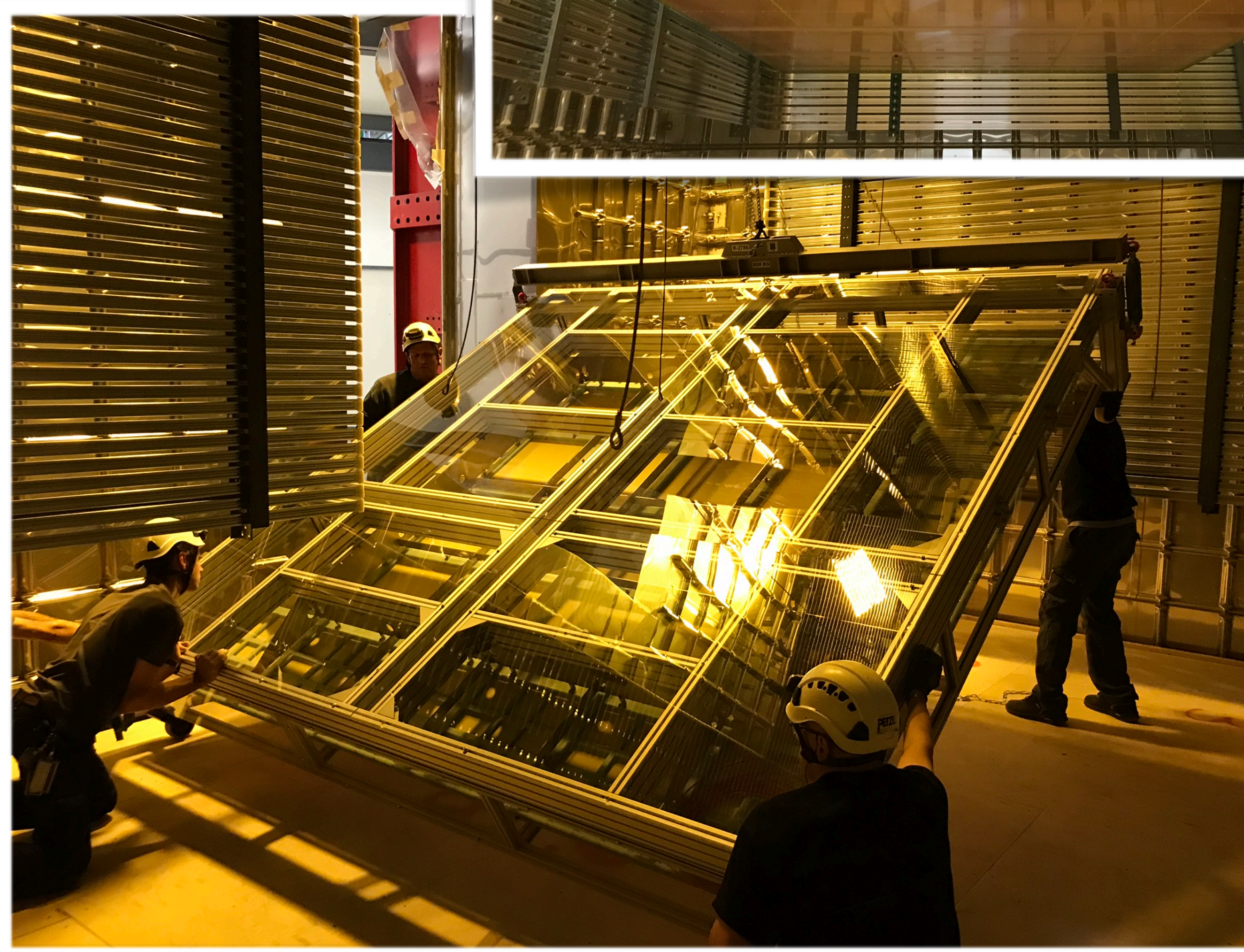
Charge readout

CRPs need always to be supported from the metal frame, therefore transportation and handling require a special clean box.
Size: 3.3 m x 3.2 m x ~0.4 m.
Weight: ~800 kg Box + CRP.
The box and CRP can be put horizontal and vertical.
HV cables installed on the CRP at the production site.
Low voltage and signal cable not yet defined.
As of today, the transport must happen with the box in horizontal position.
As of today, the boxes cannot be piled up (to be changed).
Need to store a buffer of CRPs (15 m x 15 m would be enough to store all vertically).
Before cold box test, required visual inspection and preliminary HV tests in air.

CRP and CRP box

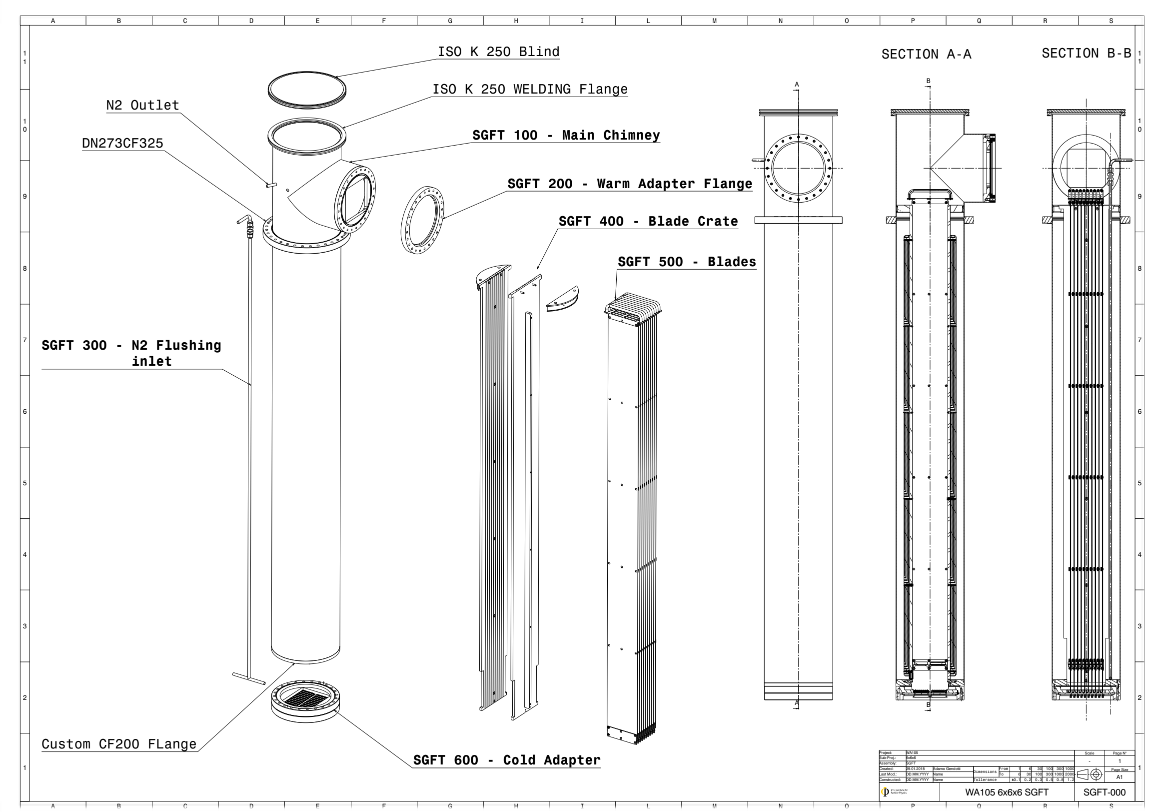






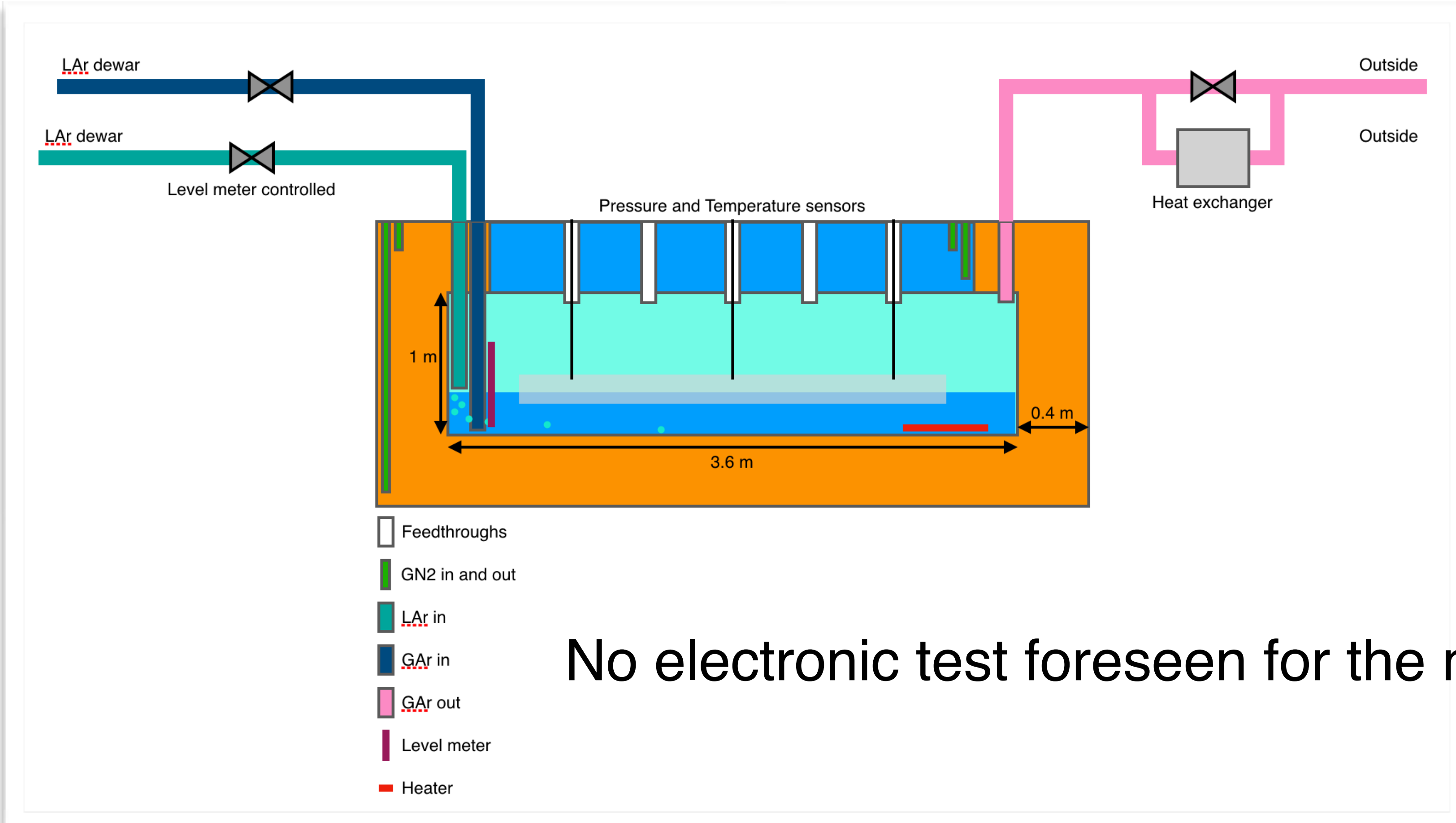
Charge readout

SGFT must be already installed at the time of the CRP installation.
960 cylinders ~2 m long 35 cm diameter < 100 kg will come in boxes (order of 2.5 m x 2 m x 1.5 m containing 12 SGFTs).
Need to store at least a buffer for two months ~30 boxes.



CRP Suspension system must be already installed at the time of the CRP installation.
240 suspensions shipped in boxes of different sizes. Assembly will happen on the roof.
Suspension system need to be mechanically tested once in place.
Again storage buffer for at least two months is needed.

NP02 cold box

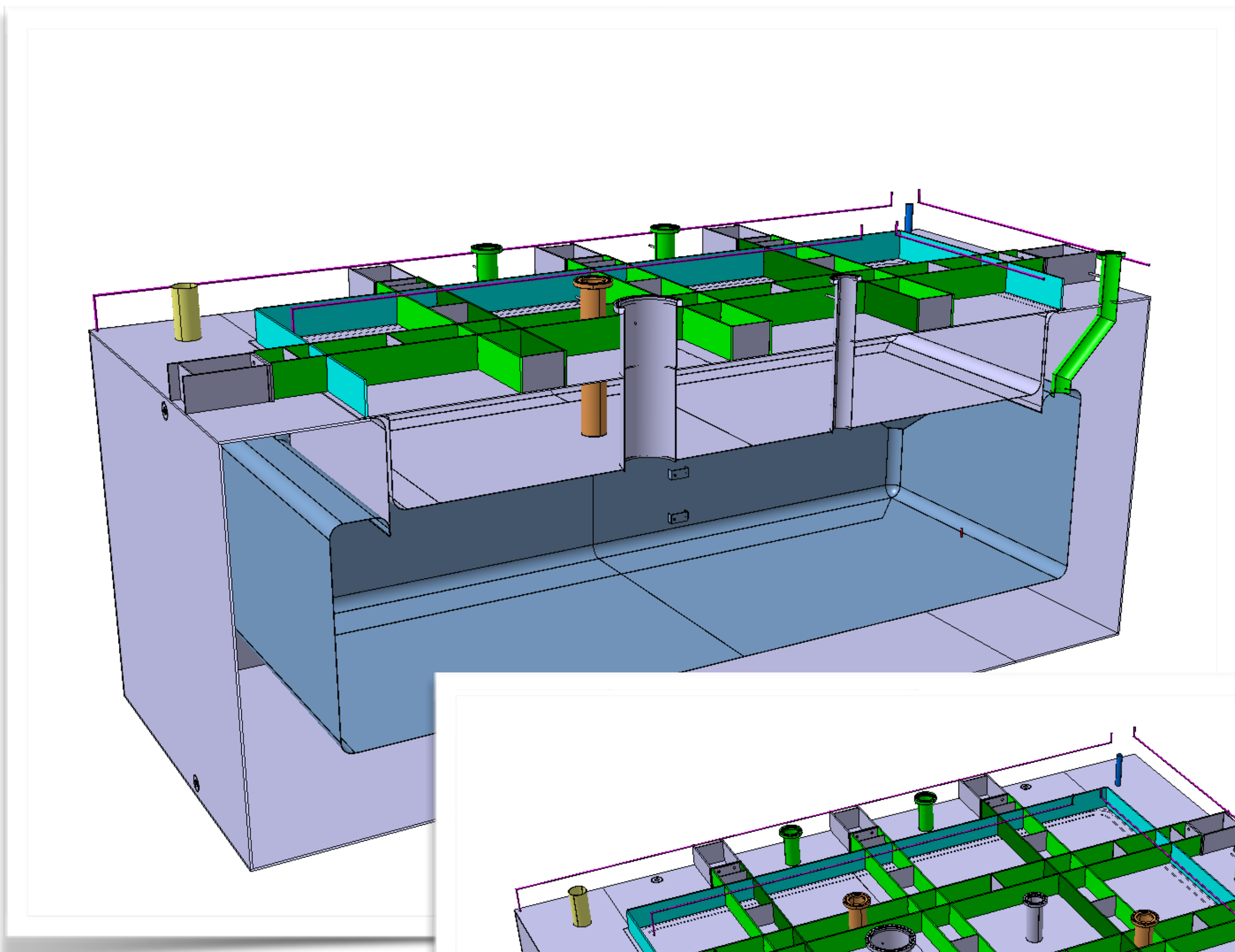


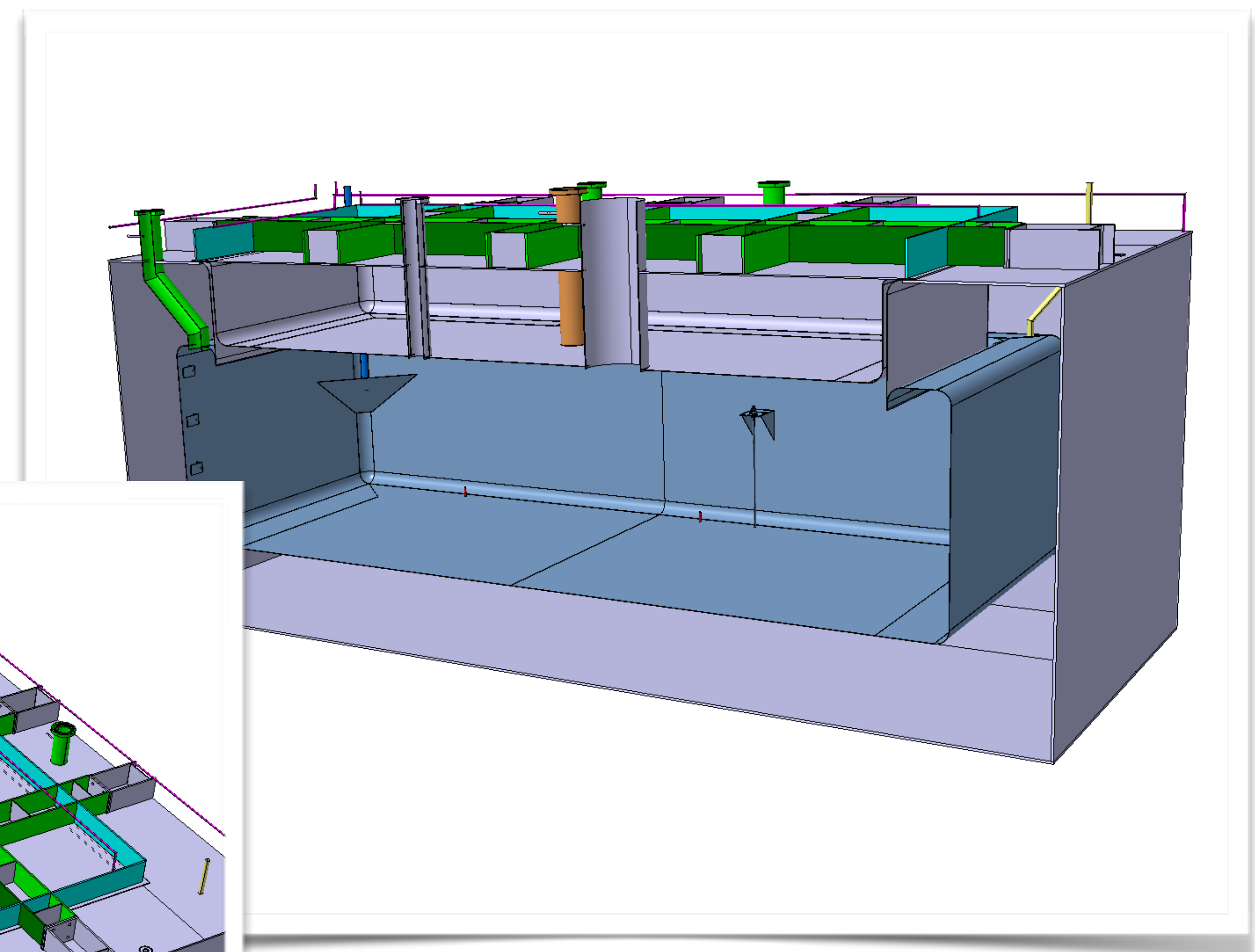
No electronic test foreseen for the moment

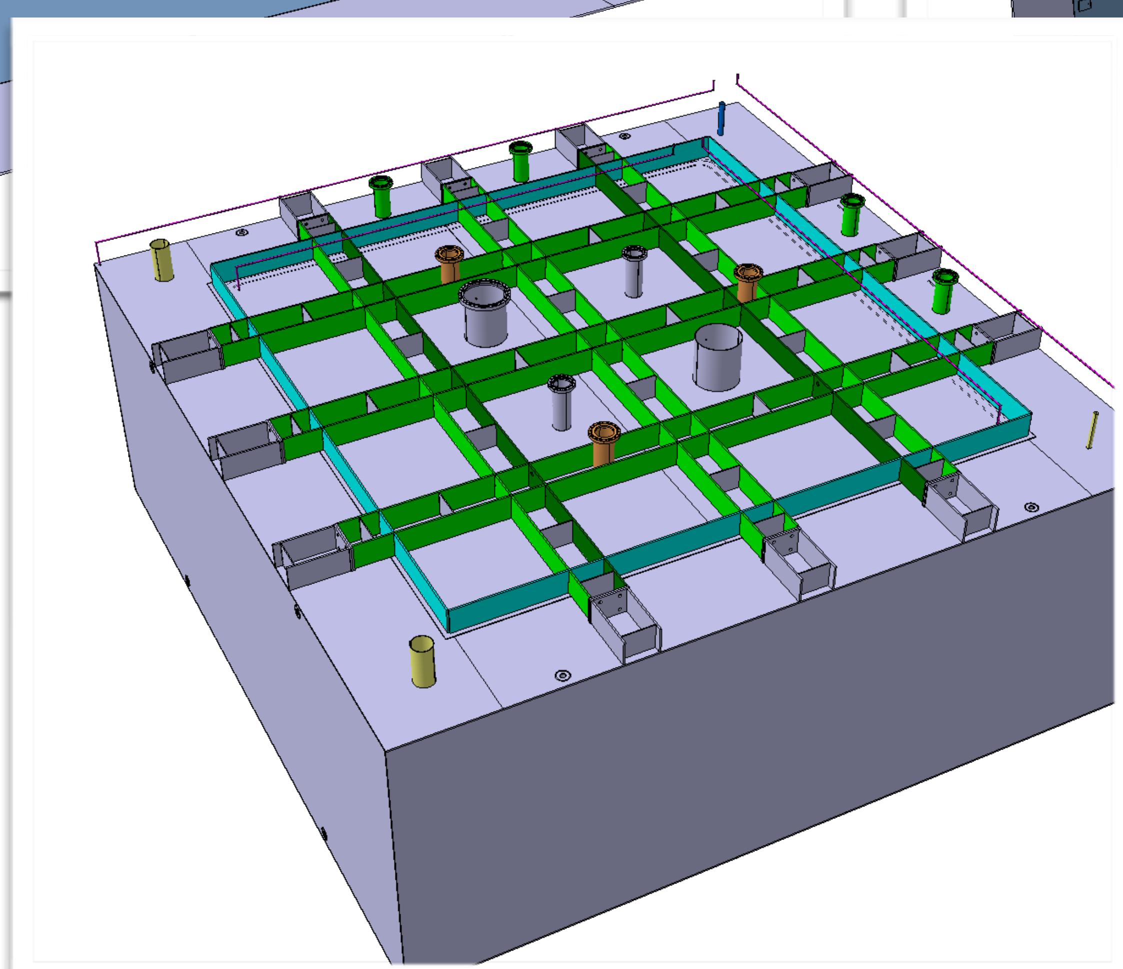
Goals: Electrical and mechanical tests of each final CRP in nominal thermodynamic conditions.

- Characterisation of the operation voltage of each LEM
- Characterisation of the operation voltage of the grid
- Test the planarity of the CRP itself
- Test the tensioning of the extraction grid wires
- Test the HV contacts and connections (LEM & grid)

Design

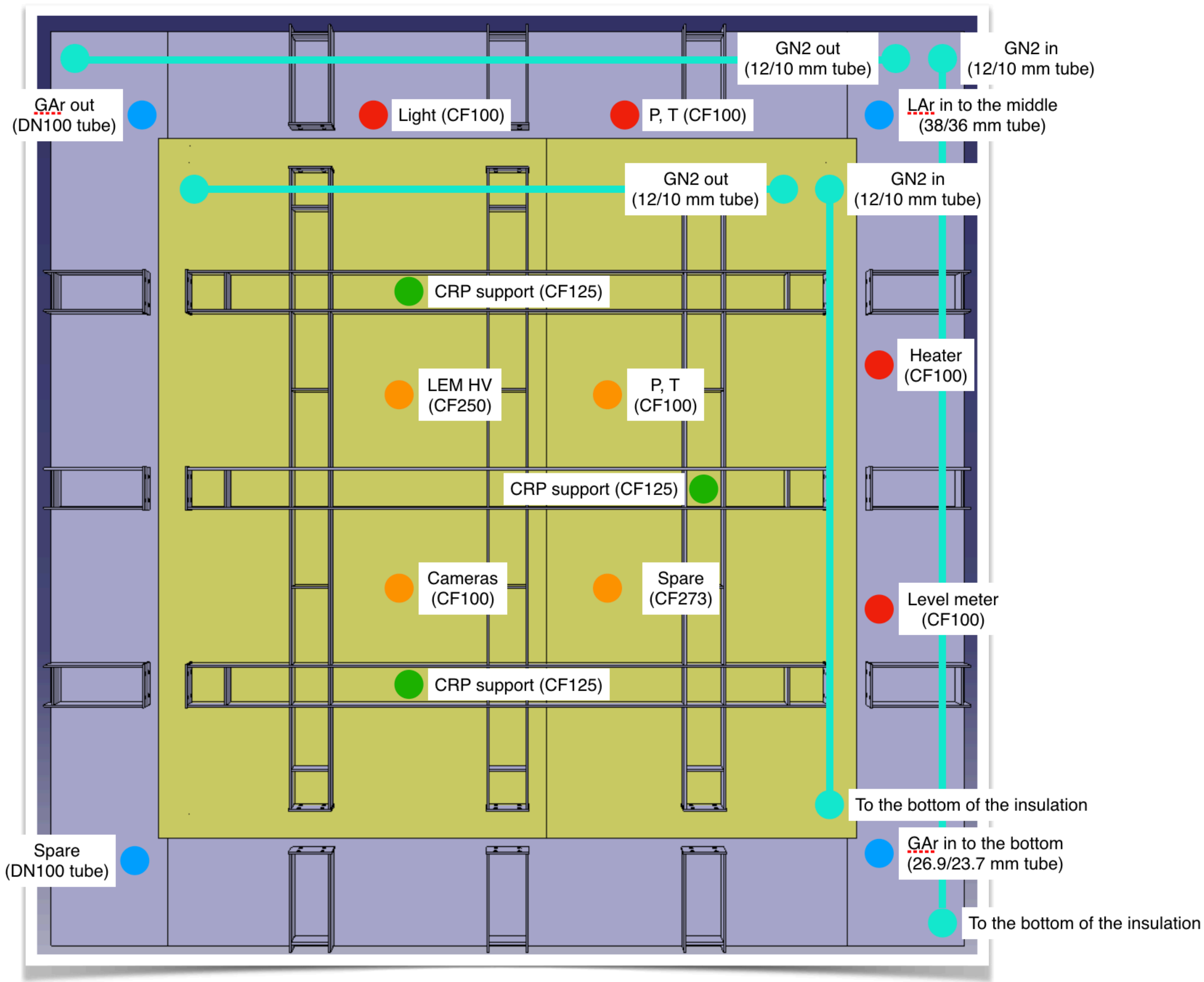




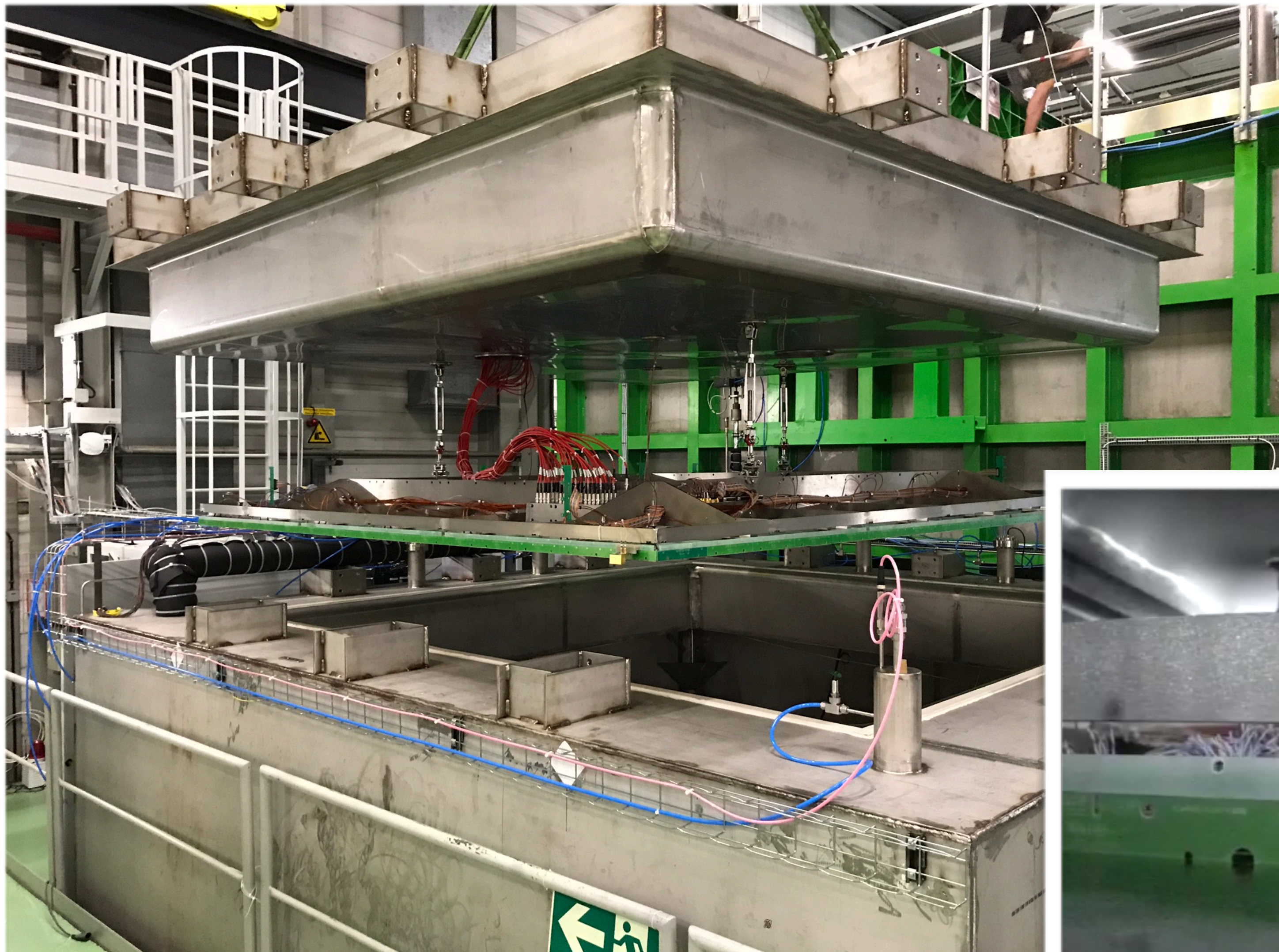


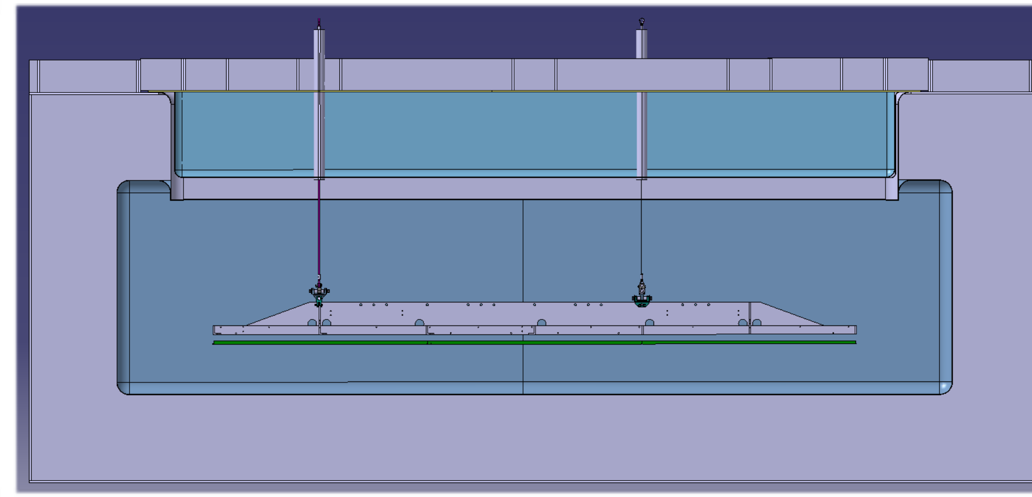
Dimensions:
- external 470 cm x 210 cm
- internal 389 cm x 99 cm
- insulation thickness 40 cm
- roof opening 333 cm x 333 cm
- roof size 360 cm x 360 cm

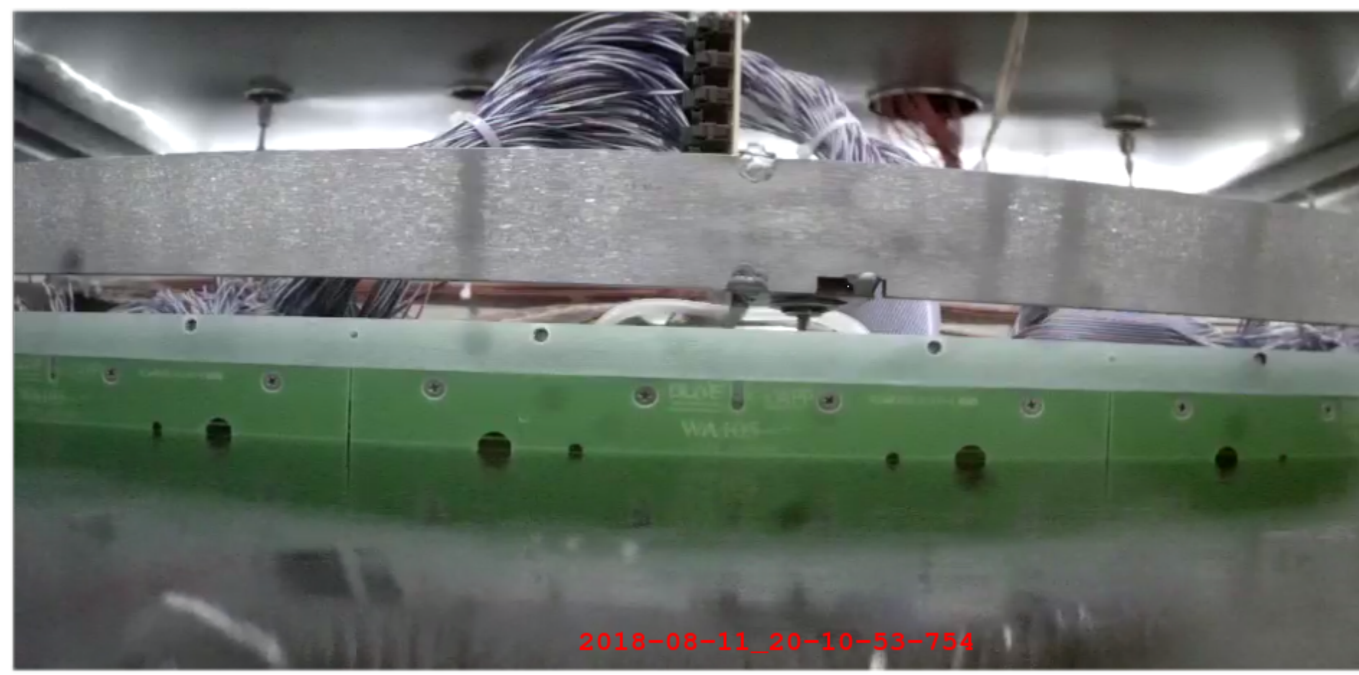
Penetrations



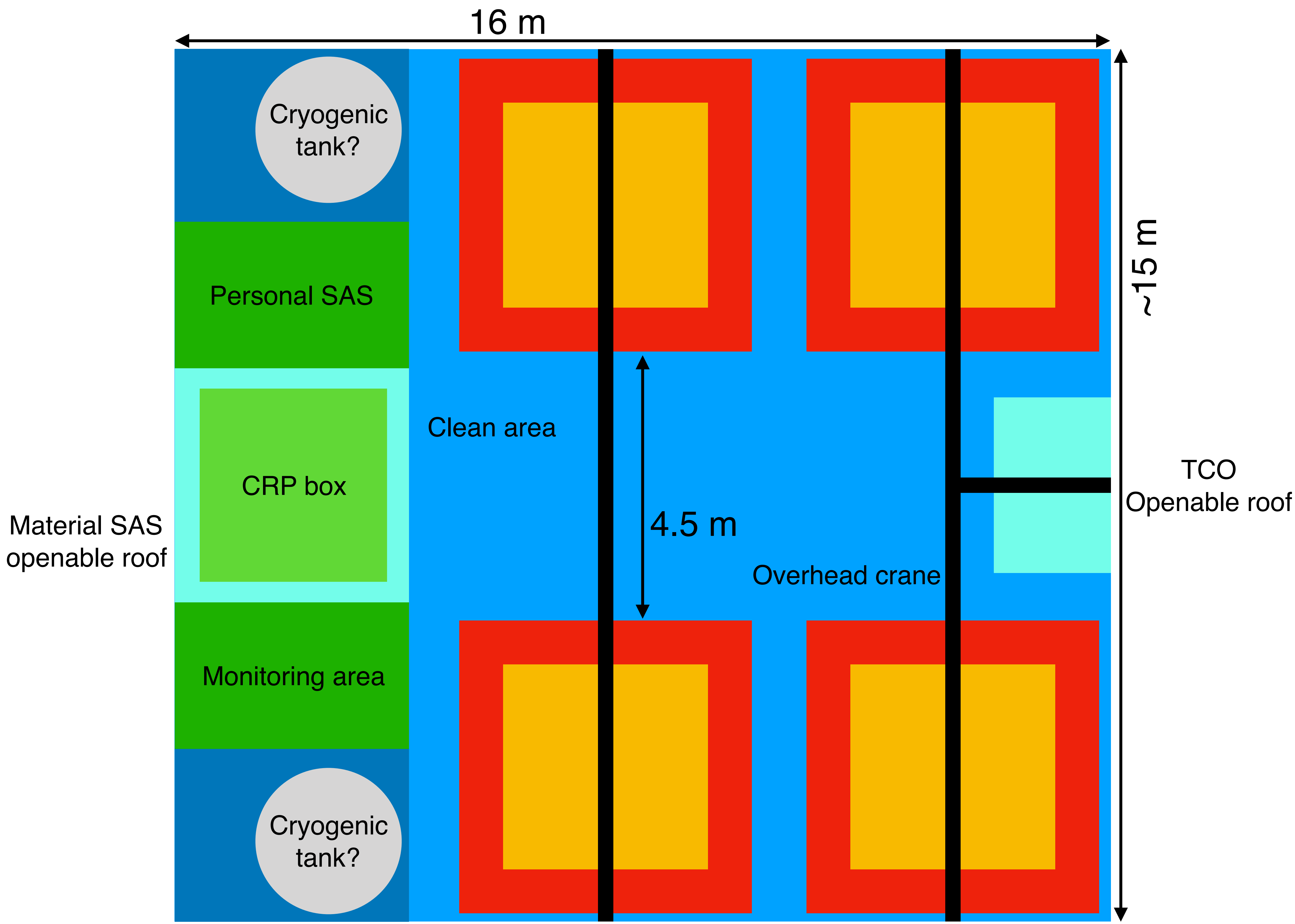
NP02 cold box







Possible clean room layout



VHV system

Field cage: long super-modules (12 m wide) constituted by sub-modules constructed inside the cryostat. Installation “lift and hang” à la NP02.

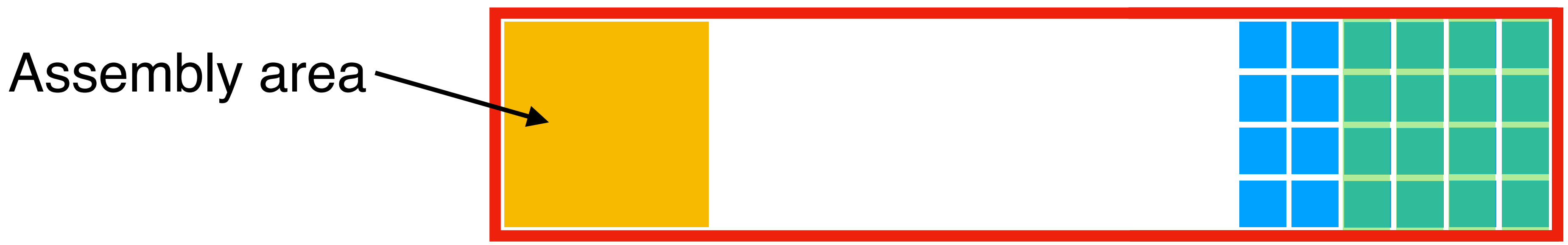
Cathode: 12 m wide sections minimising metal components used only to ensure mechanical strength and longevity. Construction inside the cryostat and hanged from the field caged bridging the long sides.

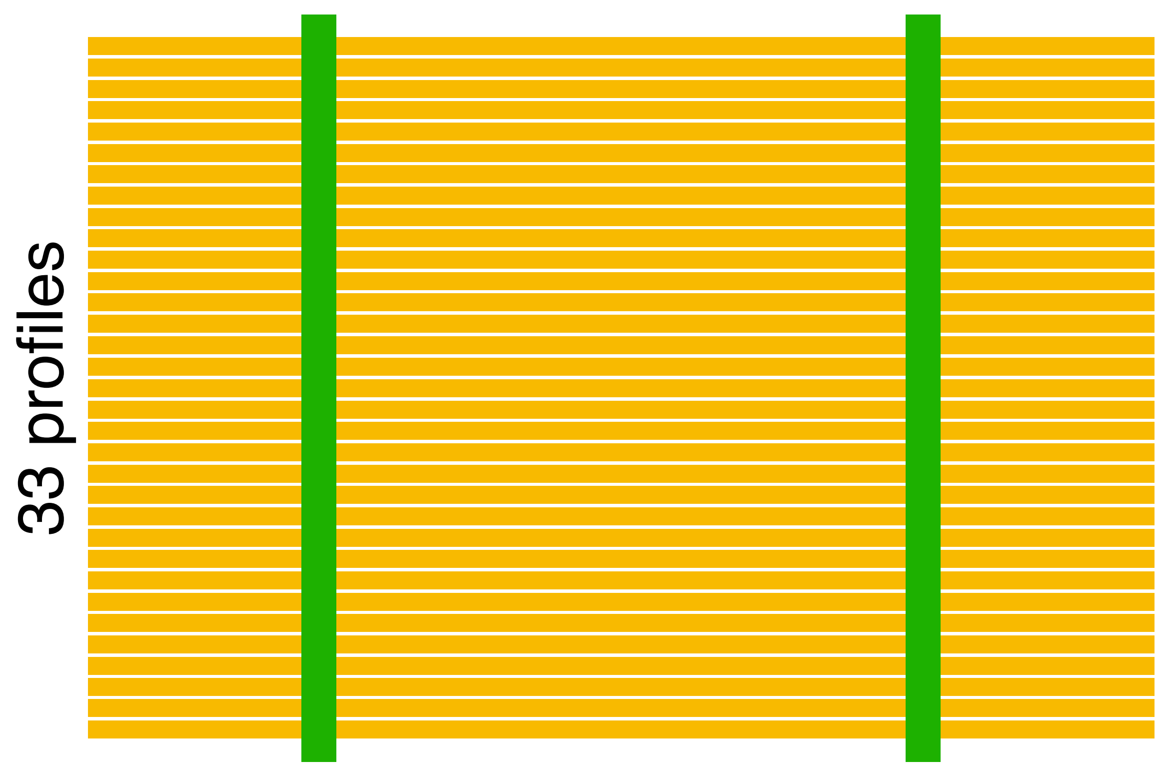
Ground grid: metal modules laying on the membrane.

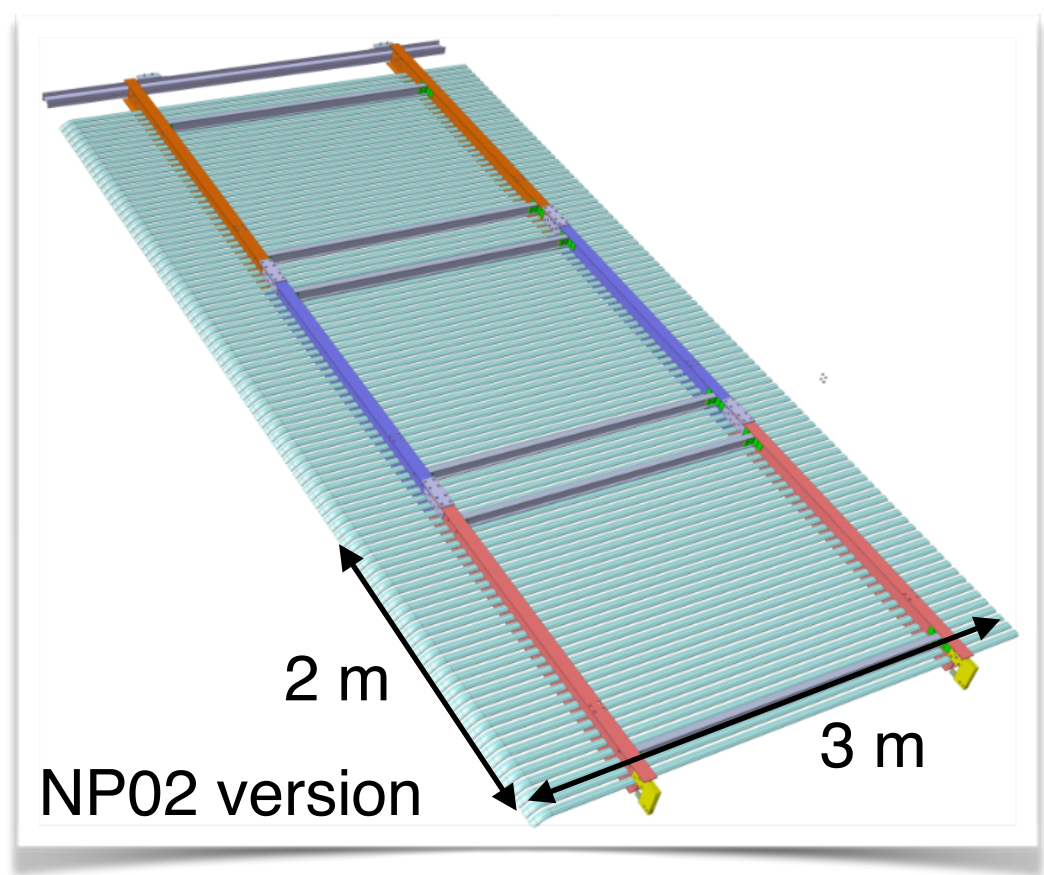
Field cage should be installed while CRPs are installed.
Cathode, ground grid and photosensors can be installed meanwhile.
Pro: speed up the installation process
Cons: no access to CRP already installed

Field cage

O(10000) aluminium profiles 3 m long shipped in boxes
O(1500) ~2.5 m long insulation I-beam shipped in boxes
Assembly of the 288 sub modules inside of the cryostat in horizontal position
4 sub-modules/day seems feasible -> 12 m x 12 m super-module installed every week

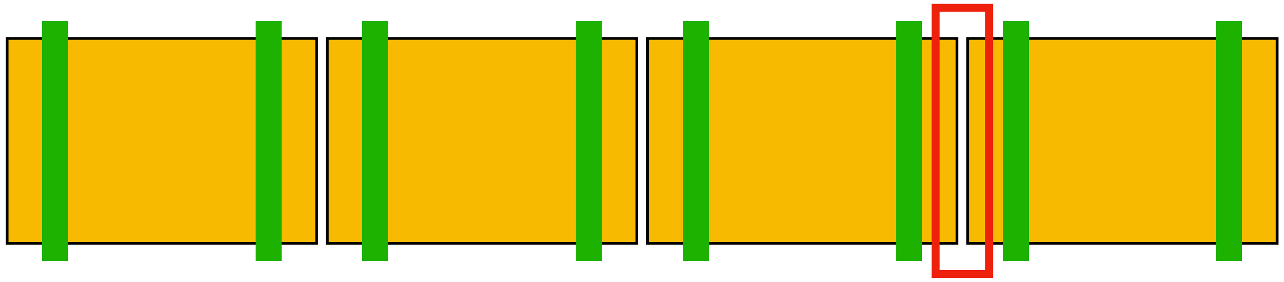






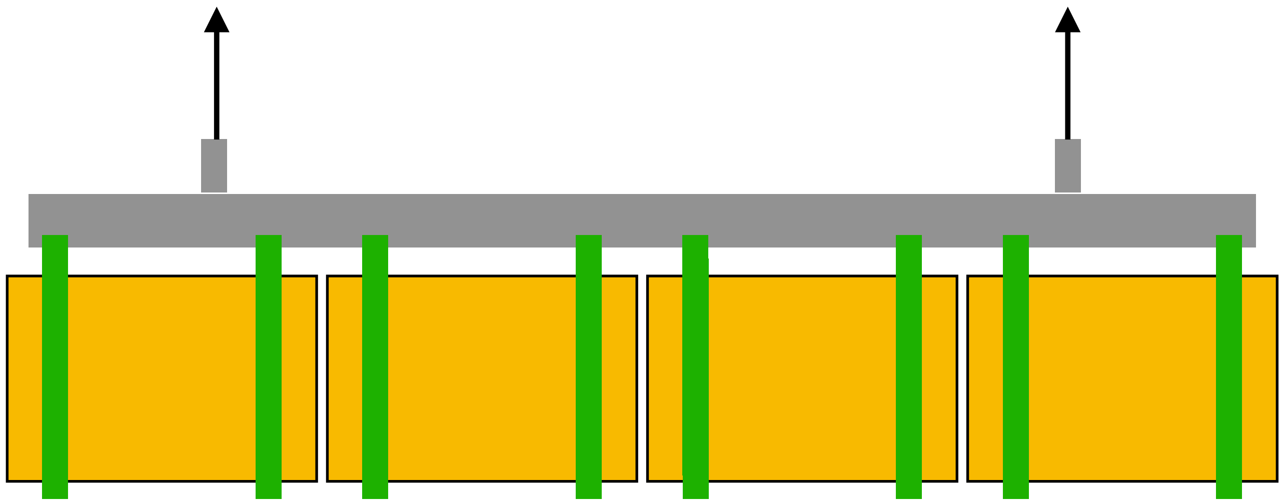
Field cage

Minimising the clipping at height: clipping 4 sub-modules together



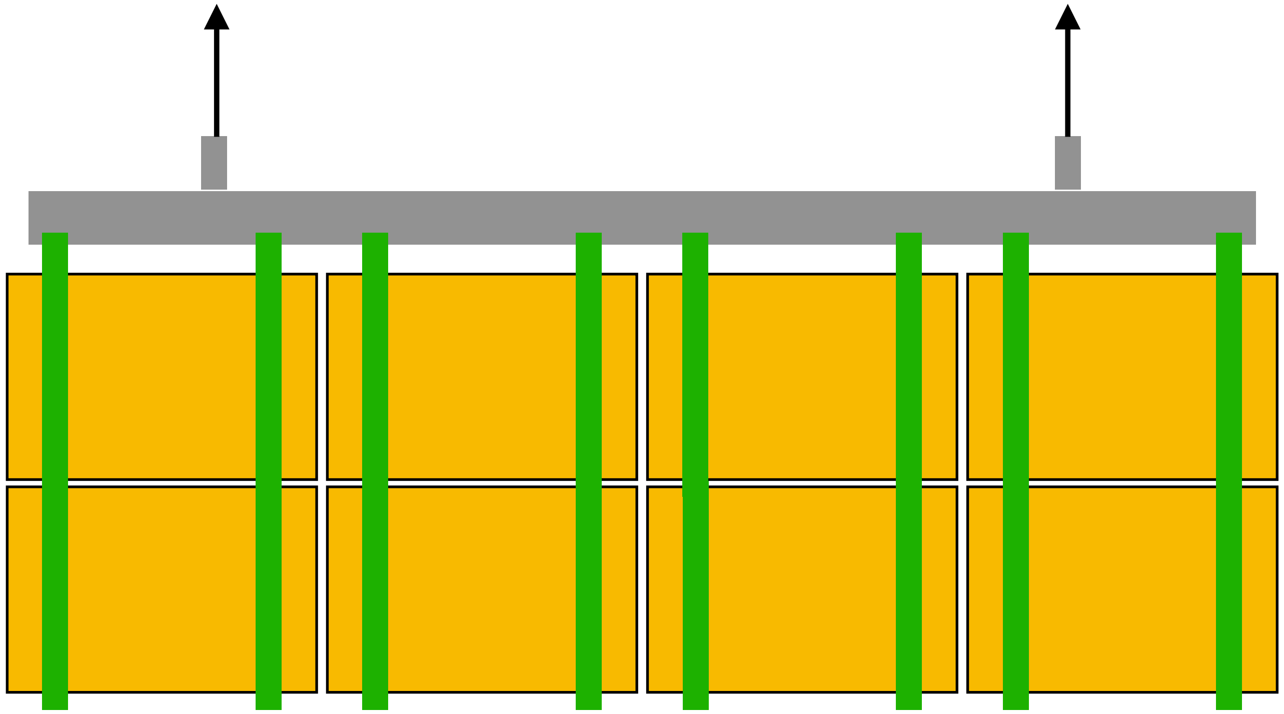
Field cage

Attach the modules to the support I beam

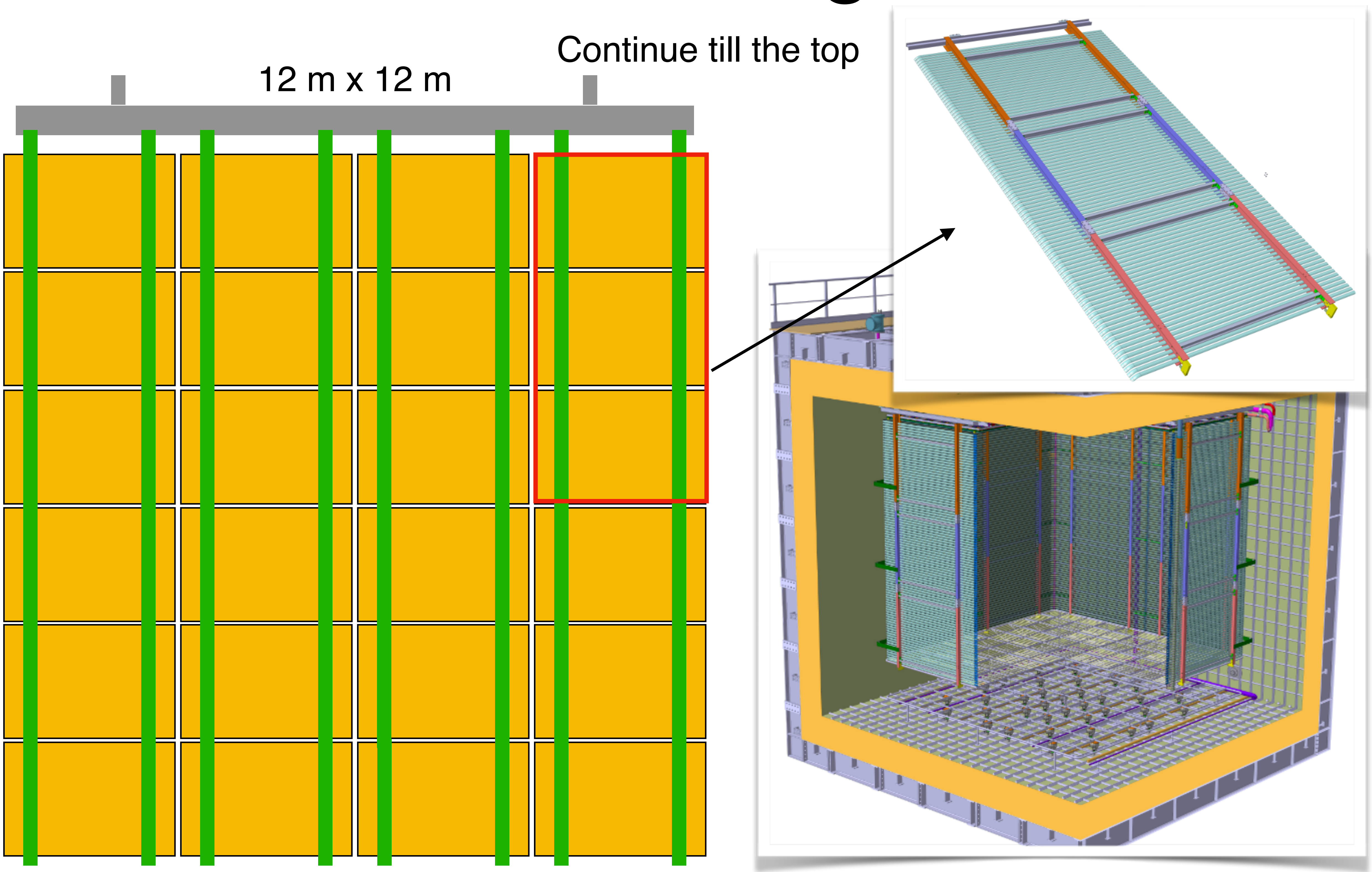


Field cage

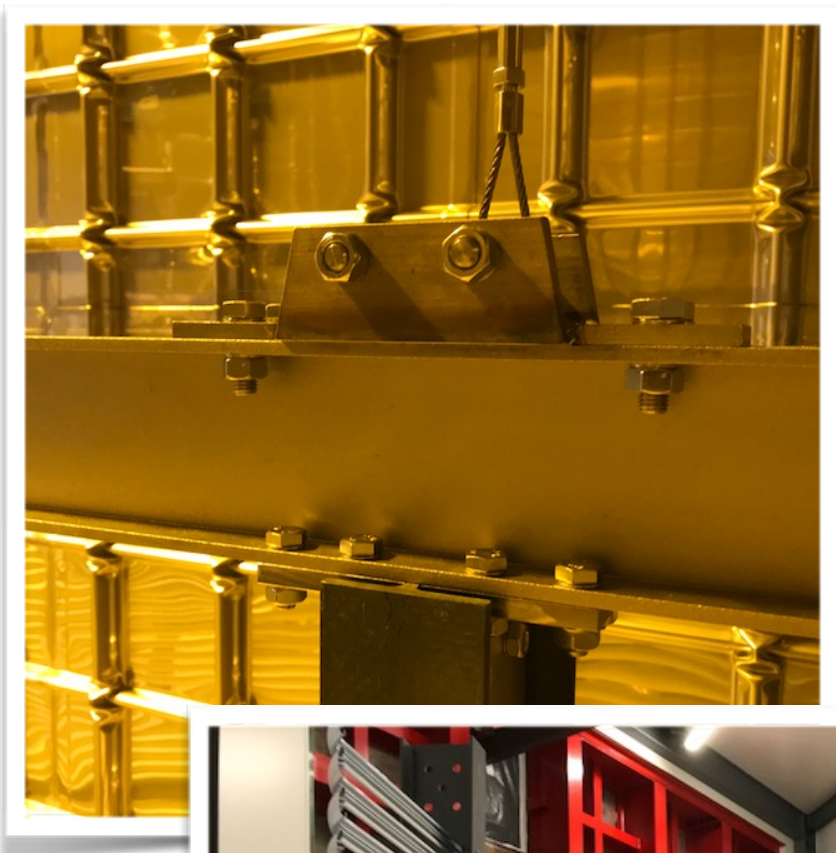
Lift the first modules and connect the second layer

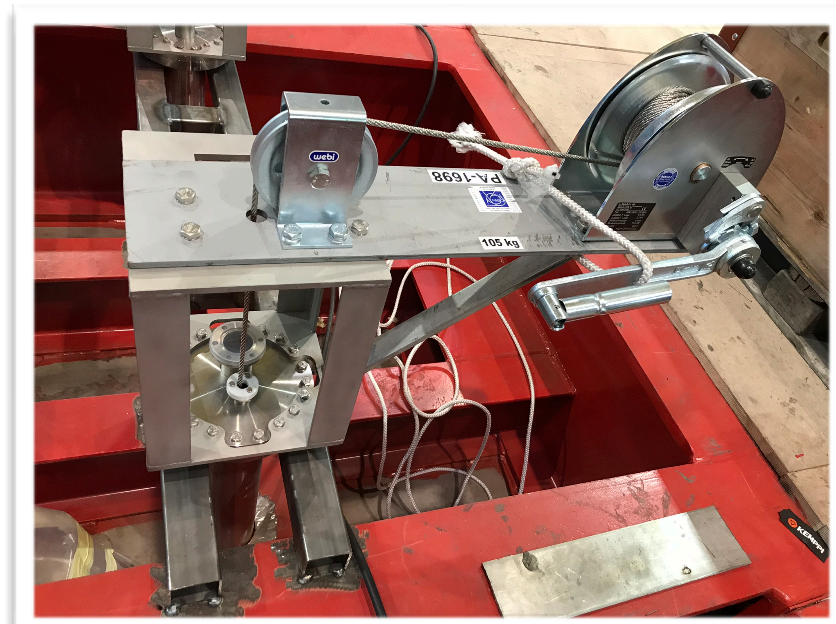


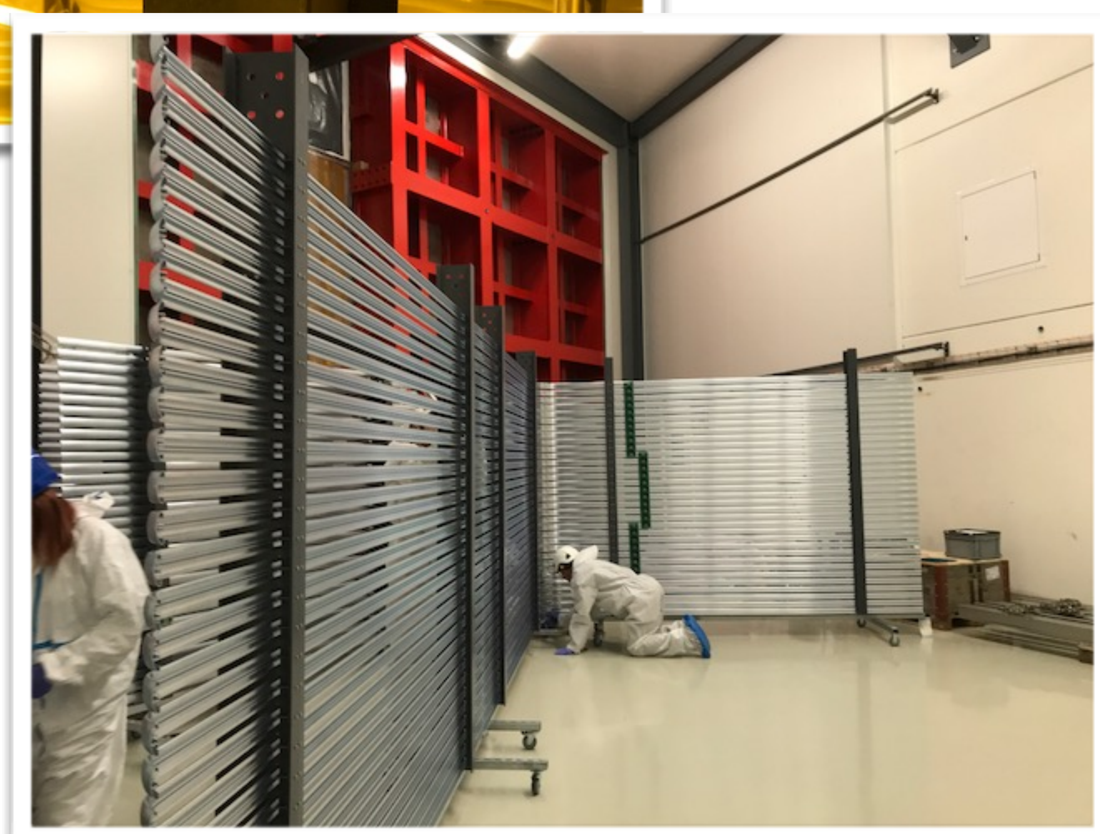
Field cage

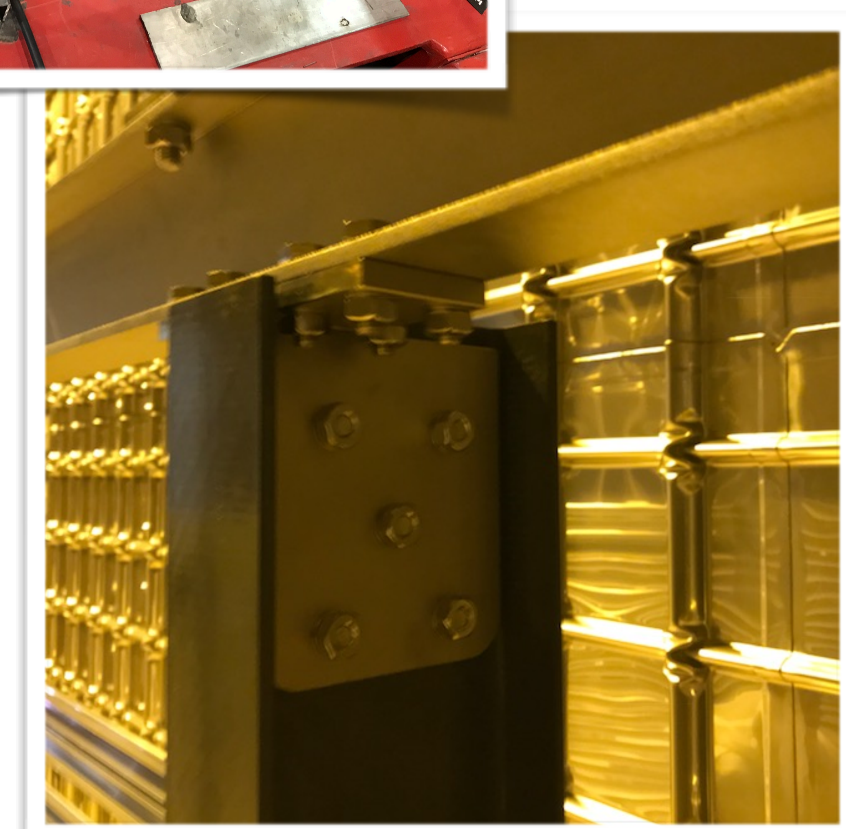


NP02 field cage

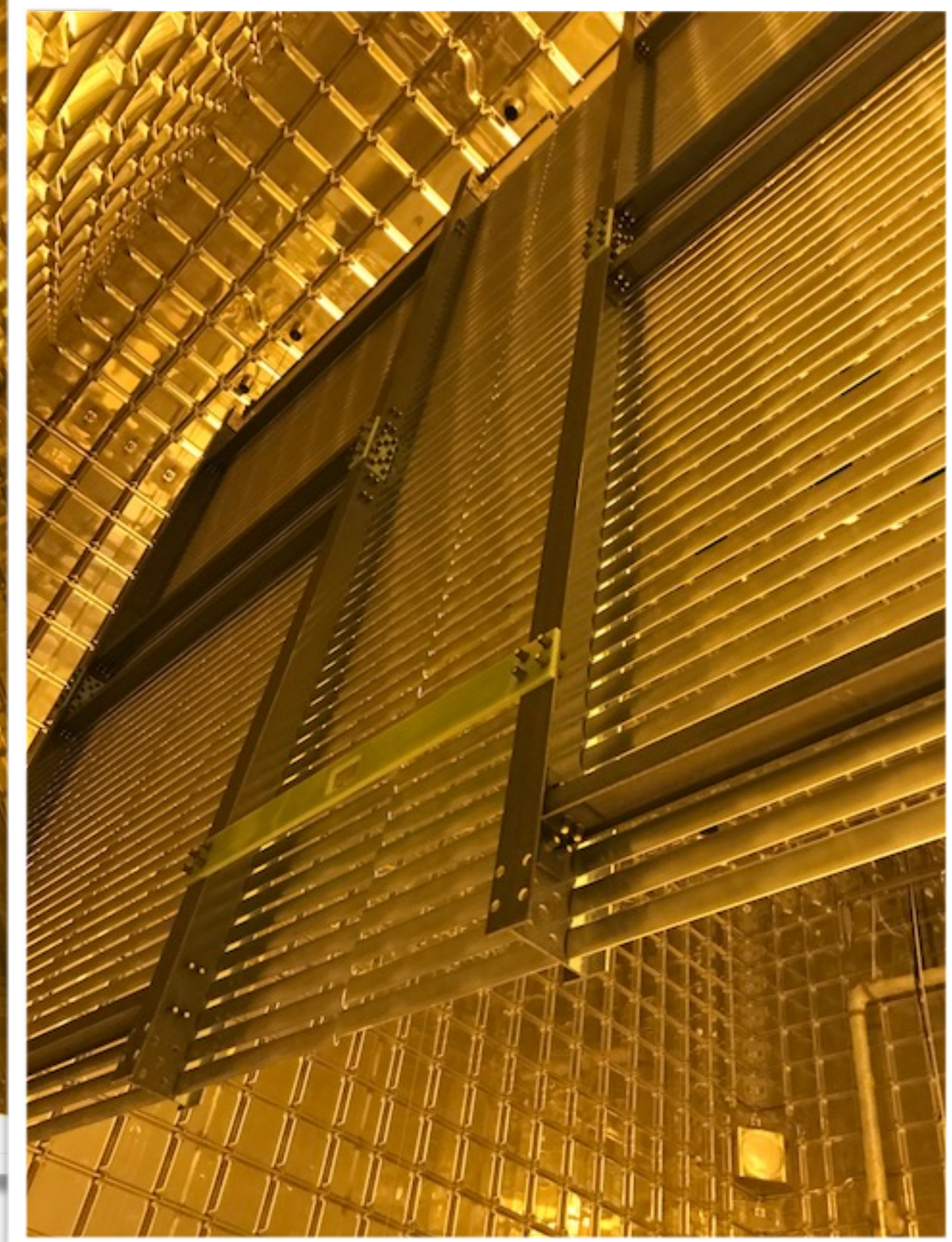






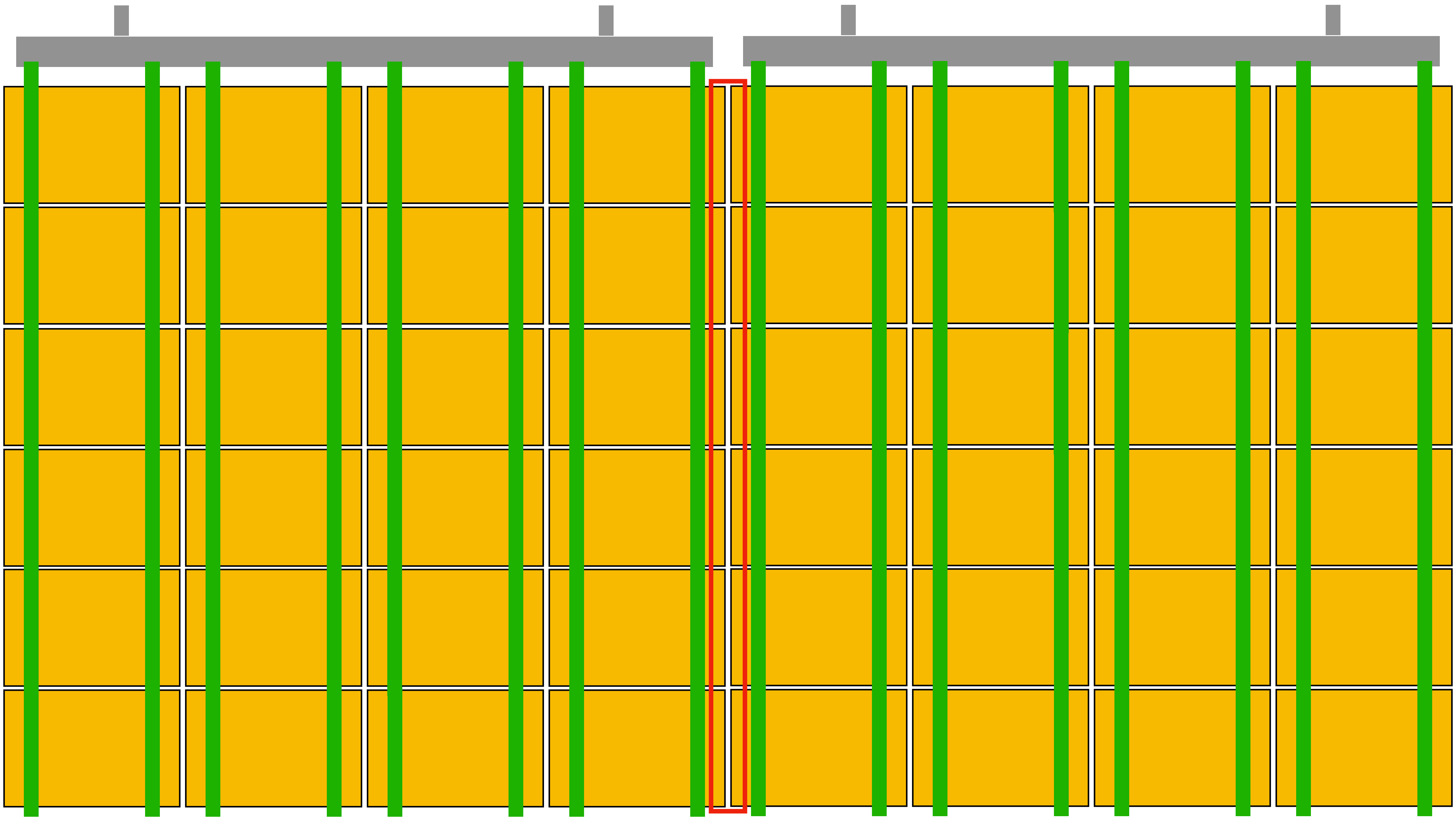


NP02 field cage



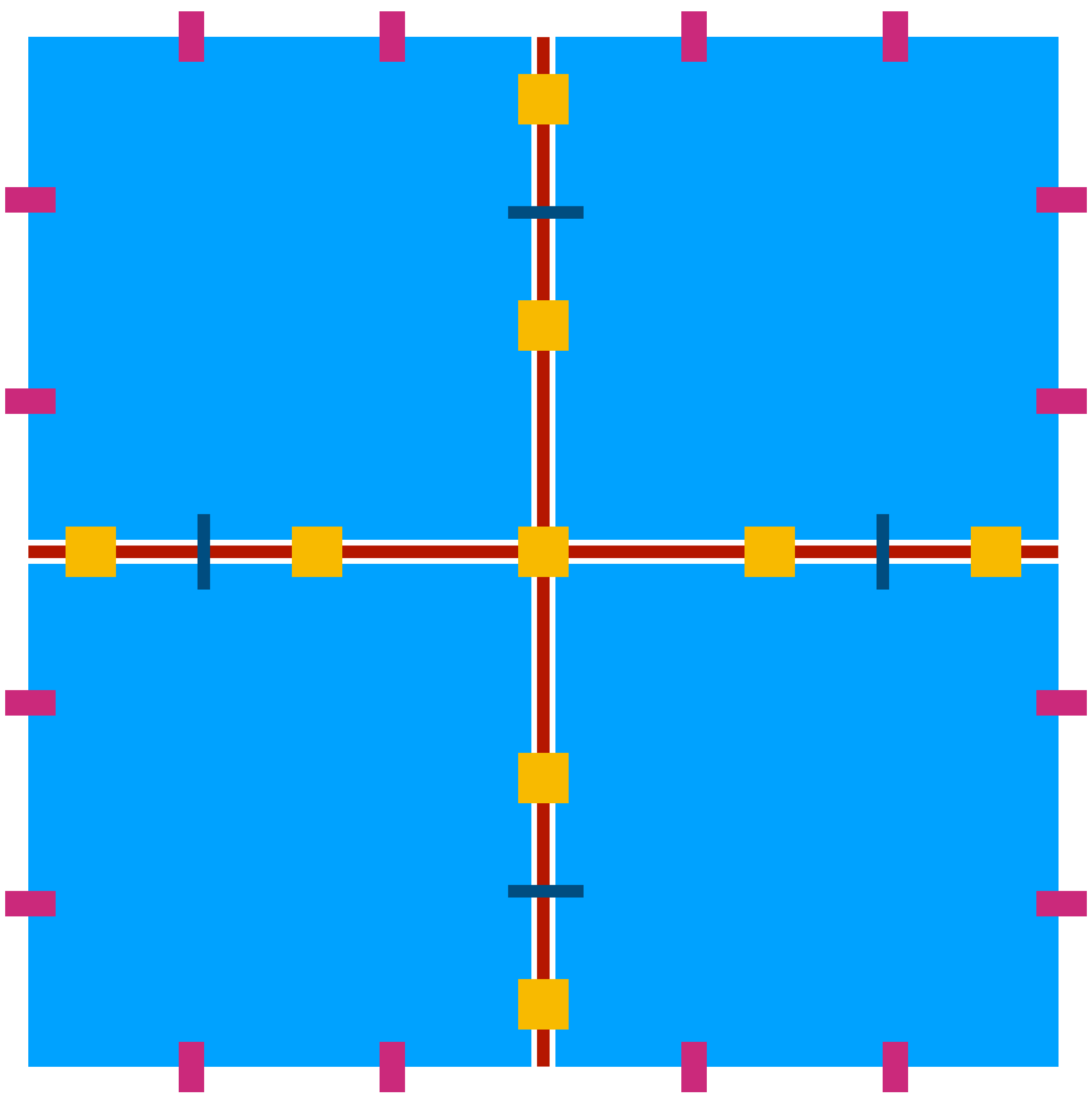
Field cage

Clipping at height 200 clips (at the moment need to access to both the sides of the field cage). Alternatively leave the super modules electrically independent and terminate the profile with insulating/resistive end-caps (single phase style). Resistive degrader every super module

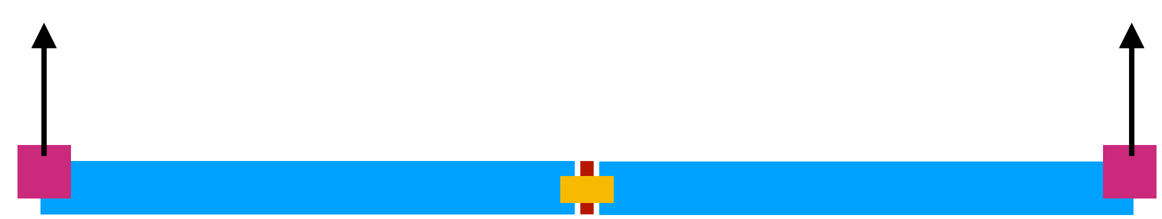


NP02 cathode: the concept

4 3x3 m^2 sub-modules to be assembled inside the cryostat
Hanging from the field cage. Flatness and sagging +/- 1 cm

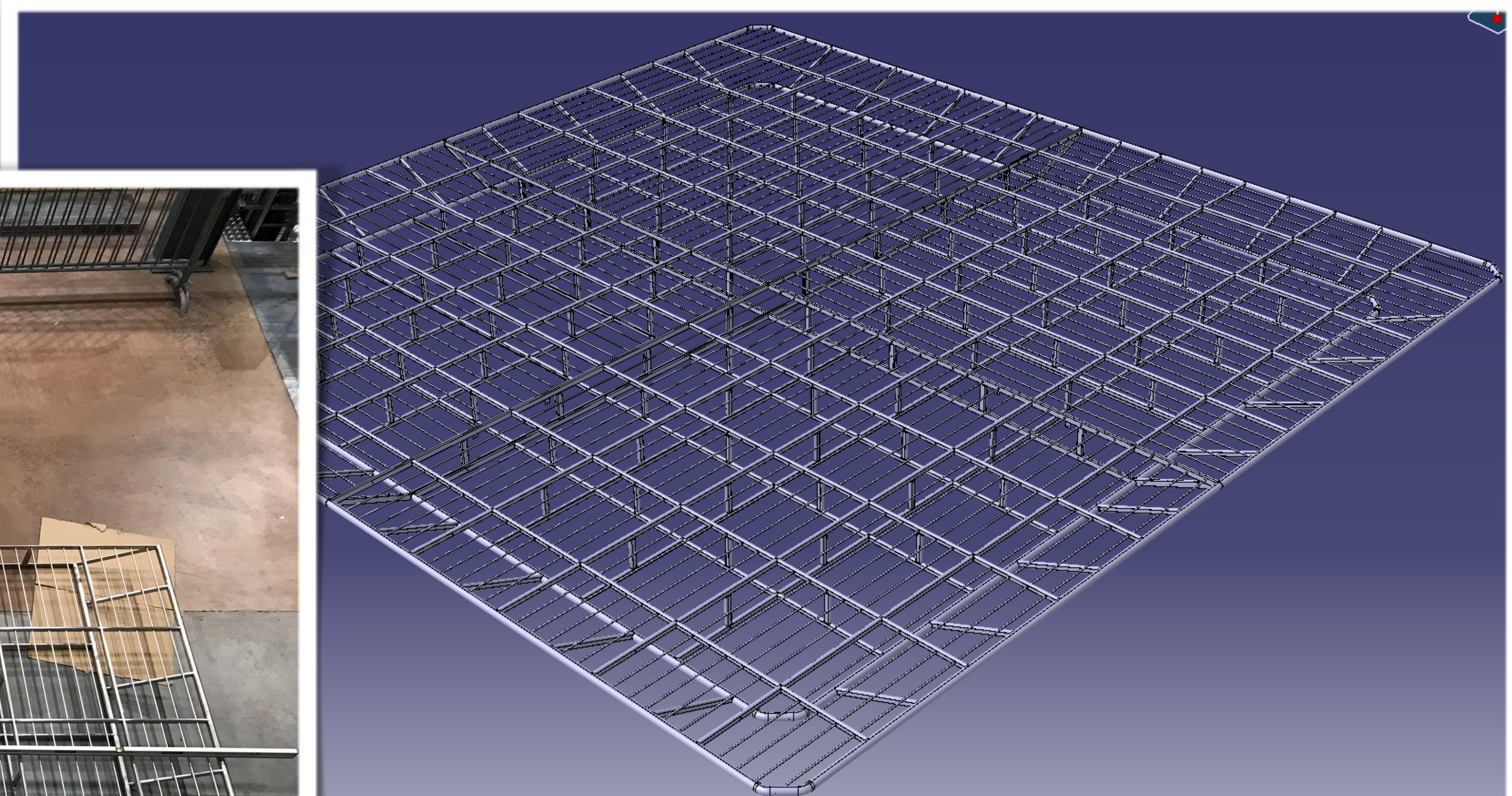


- sub-modules
- hanging points
- mechanical connections
- dielectric insulation
- resistive connection



NP02 cathode

Cathode will be powered at -300 kV. Composed by 4 identical sections mechanically assembled together during installation. Electrically the 4 parts are connected via dumping resistors. 6 m x 6 m cathode is held only at the edges (scalable concept). All the material available at EHN1. 4 bottom section completed. Production of the top layer follows. Ground grid as PMT protection has the same construction philosophy



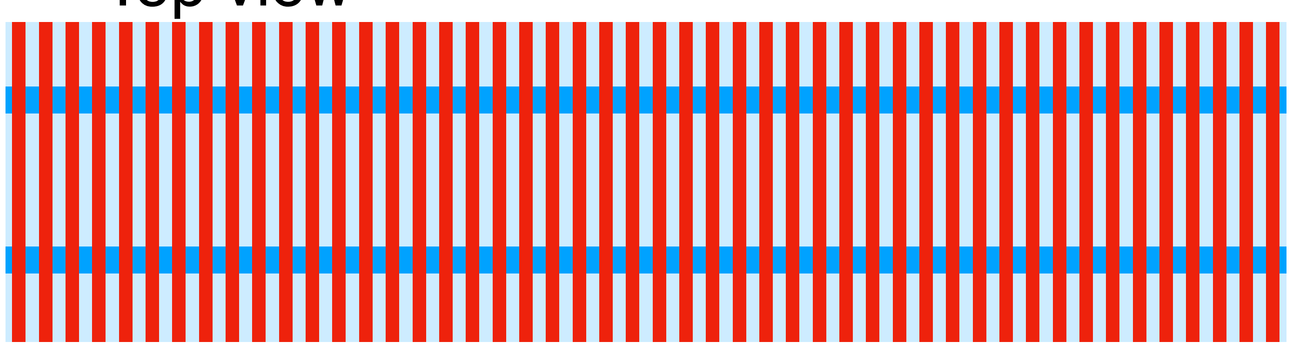
DUNE-DP cathode

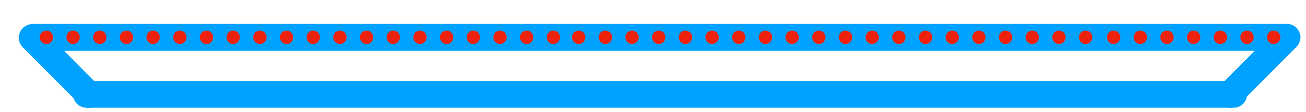
Extrapolate the NP02 concept to DUNE is possible.

There is the will to replace the metal grid with resistive surfaces.
12 m x 3 m super-modules are assembled inside the cryostat and hanged to the field cage.
Studies are ongoing to optimise the design to protect the system from discharges.
Metal mechanical sporting structure 12 m long and hanging from the field cage.
They will be delivered in pieces and assembled inside the cryostat.

Two possibilities for the resistive cathode surface:
- Resistive rods running orthogonal to the supporting structure.
- Acrylic tiles deposited with transparent resistive polymer and wavelength shifter.

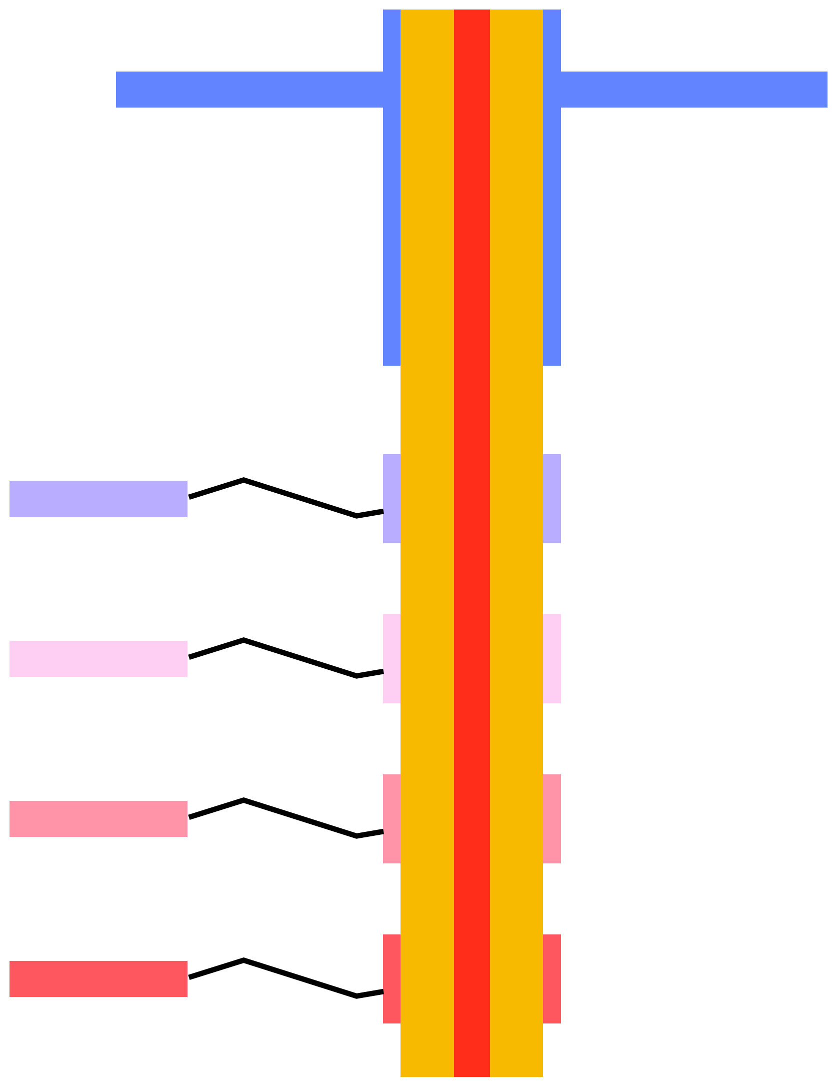
Top view



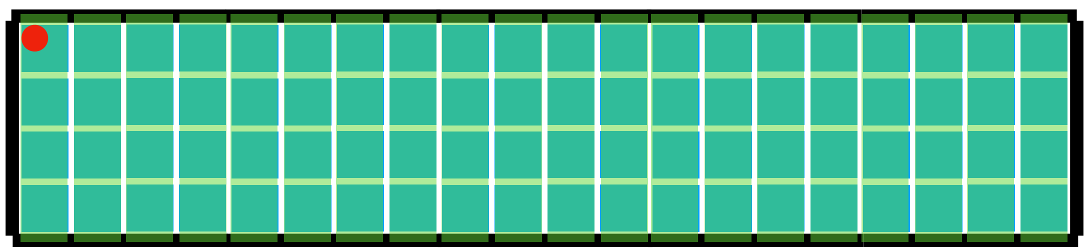


Side view

VHV feedthrough



Thinking to the possibility of installing the feedthrough inside the active volume through one of the CRPs



Shipped in boxes pre-assembled and tested at production sites. Only to be installed.

~15 m long ‘cylindrical’ structure composed of:
- 600 kV vacuum tight feedthrough similar in concept to NP02 feedthrough (300 kV rated)
- extender/degrader to bring the HV to the cathode and reduce the electric field

The field shapers are connected to the profiles of the field cage minimising the electric field in LAs

Racks

Partial list:
- Charge readout -> 12x 80 small racks next to the SGFTs
- Light readout -> ~20 racks
- CRP movement -> ~10 racks
- LEM HV PS -> ~10 racks
- Detector safety system -> 5 racks?
- Instrumentation -> 10 racks?
- Detector control system -> 10 racks?
- Rack power distribution -> 5 racks?
- VHV power supply -> 1 rack on the roof